

CLAIMS

1. A process for forming diffusion aluminide coatings on an uncoated surface of a substrate, without interdiffusing a sufficient amount of aluminum into a coating layer to adversely affect the coating growth potential or mechanical properties of said coating layer, comprising the steps of:
  - providing a metal substrate comprising an external surface and an internal passage therein defined by an internal surface, at least a portion of the external surface of the substrate being coated with a coating layer selected from the group consisting of  $\beta$ -NiAl-base, MCrAlX, a line-of sight diffusion aluminide, a non-line-of-sight diffusion aluminide, a pack diffusion aluminide, and a slurry diffusion aluminide on said substrate;
  - cleaning the external surface of the substrate;
  - subjecting the metal substrate to a aluminum vapor phase deposition process performed using a fluorine-containing activator selected from the group consisting of  $\text{AlF}_3$ ,  $\text{CrF}_3$ ,  $\text{NH}_4\text{F}$ , and combinations thereof, at a rate in the range of about 0.036 mols of fluorine per  $\text{ft}^3/\text{hr}$  of transport gas to about 0.18 mols of fluorine per  $\text{ft}^3/\text{hr}$  of transport gas, at a temperature in the range of about  $1350^\circ\text{F}$  to about  $1925^\circ\text{F}$ , using a transport gas selected from the group consisting of argon, nitrogen, hydrogen, and combinations thereof, the transport gas being provided at a flow rate in the range of about  $20 \text{ ft}^3/\text{hr}$  to about  $120 \text{ ft}^3/\text{hr}$  for a period of time in the range of about 2 hours to about 10 hours; and
  - cooling the substrate.
2. The process of claim 1, wherein the coating layer is a  $\beta$ -NiAl-base layer.
3. The process of claim 2, wherein the coating layer is a  $\beta$ -NiAlCrZr layer.
4. The process of claim 3, wherein the  $\beta$ -NiAlCrZr coating layer comprises about 53.5 weight percent nickel to about 64.5 weight percent nickel, about 20 weight to about

- 30 weight percent aluminum, about 2 weight percent to about 15 weight percent chromium, and about 0.5 weight percent to about 1.5 weight percent zirconium.
5. The process of claim 4, wherein the  $\beta$ -NiAlCrZr coating layer comprises about 60 weight percent nickel, about 27 weight percent aluminum, about 12 weight percent chromium, and about 1 weight percent zirconium.
  6. The process of claim 1, wherein the coating layer is a non-line-of-sight diffusion aluminide layer comprising aluminum, chromium, and a material selected from the group consisting of a reactive element, a noble metal, and combinations thereof.
  7. The process of claim 1, wherein the coating is a pack diffusion aluminide layer comprising aluminum, chromium, and a material selected from the group consisting of a reactive element, a noble metal, and combinations thereof.
  8. The process of claim 1, wherein the coating is a slurry diffusion aluminide layer comprising aluminum, chromium, and a material selected from the group consisting of a reactive element, a noble metal, and combinations thereof.
  9. The process of claim 1, wherein the coating layer is MCrAlX, where M is a metal selected from the group consisting of iron, cobalt, nickel, and combinations thereof.
  10. The process of claim 1 further comprising the additional step of densifying and smoothing the coating layer using a shot peen treatment prior to the step of cleaning the external surface of the substrate.
  11. The process of claim 1 further comprising the additional step of masking a preselected external portion of the substrate prior to the step of subjecting the metal substrate to an aluminum vapor phase deposition process.
  12. The process of claim 1 further comprising the additional step of subjecting the coating layer to a surface finish treatment to reduce the roughness of the coating layer.
  13. The process of claim 1 further comprising the additional step of applying a thermal bond coat to the coating layer.

14. The process of claim 12 further comprising the additional step of applying a thermal bond coat to the coating layer.
15. The process of claim 1, wherein the aluminum vapor phase deposition process is performed using an  $\text{AlF}_3$  activator at a rate of 0.036 mols of fluorine per  $\text{ft}^3/\text{hr}$  of transport gas, at a temperature of about  $1900^\circ\text{F}$ , the transport gas being provided at a flow rate of about  $20 \text{ ft}^3/\text{hr}$  for a period of time of about 6 hours.
16. The process of claim 4, wherein the aluminum vapor phase deposition process is performed using an  $\text{AlF}_3$  activator at a rate of 0.036 mols of fluorine per  $\text{ft}^3/\text{hr}$  of transport gas, at a temperature of about  $1900^\circ\text{F}$ , the transport gas being provided at a flow rate of about  $20 \text{ ft}^3/\text{hr}$  for a period of time of about 6 hours.
17. The process of claim 5, wherein the aluminum vapor phase deposition process is performed using an  $\text{AlF}_3$  activator at a rate of 0.036 mols of fluorine per  $\text{ft}^3/\text{hr}$  of transport gas, at a temperature of about  $1900^\circ\text{F}$ , the transport gas being provided at a flow rate of about  $20 \text{ ft}^3/\text{hr}$  for a period of time of about 6 hours.
18. A superalloy article comprising:
  - a substrate, comprising an external surface and an internal passage therein defined by a internal surface, both the internal surface and the external surface having been low in aluminum content immediately after initial manufacture of the superalloy article;
  - a first aluminum-rich layer being present on the external surface, the first aluminum-rich layer having been applied to the external surface after initial manufacture, the first aluminum-rich layer making the external surface aluminum-rich and forming an aluminum-rich surface on the external surface, with the internal surface remaining low in aluminum content after the application of the aluminum-rich layer to the external surface; and
  - a second aluminum-rich layer being present on the internal surface, the second aluminum-rich layer having been applied to the external surface after the application of the first aluminum-rich layer, the second aluminum-rich

layer having been applied by exposing both the external surface and the internal surface to an aluminum-rich atmosphere, such exposure depositing aluminum onto and diffusing aluminum into the internal surface without the already aluminum-rich first external surface undergoing a phase change and without depositing sufficient aluminum onto and sufficient aluminum into the external surface to adversely affect the coating growth potential and mechanical properties of the first aluminum-rich layer.

19. The superalloy article of claim 18, wherein the superalloy article is a turbine blade.
20. A superalloy article coated with a diffusion aluminide layer using the process of claim 1.
21. A turbine engine component comprising:

- a superalloy substrate, comprising a surface, the surface having been low in aluminum content immediately after initial manufacture of the superalloy article;

- a first aluminum-rich layer being present on a first portion of the surface, the first aluminum-rich layer having been applied to the first portion of the surface after initial manufacture, the first aluminum-rich layer making the first portion of the surface aluminum-rich and forming an aluminum-rich surface on the first portion of the surface, with a second portion of the surface remaining low in aluminum content after the application of the aluminum-rich layer to the first portion of the surface; and

- a second aluminum-rich layer being present on a second portion of the surface, the second aluminum-rich layer having been applied to the second portion of the surface after the application of the first aluminum-rich layer, the second aluminum-rich layer having been applied by exposing both the first portion of the surface and the second portion of the surface to an aluminum-rich atmosphere, such exposure depositing aluminum onto and diffusing aluminum into the second portion of the surface without the already aluminum-rich first portion of the surface undergoing a phase change and

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without depositing sufficient aluminum onto and sufficient aluminum into the first portion of the surface to adversely affect the coating growth potential and mechanical properties of the first aluminum-rich layer.

- 22. The turbine engine component of claim 21, wherein the component is a turbine vane.
- 23. The turbine engine component of claim 21, wherein the component is a deflector.
- 24. The turbine engine component of claim 21, wherein the component is a centerbody.
- 25. The turbine engine component of claim 21, wherein the component is a splash plate.
- 26. The turbine engine component of claim 21, wherein the component is a shroud.
- 27. The turbine engine component of claim 21, wherein the component is a turbine blade.